Diamond Scattering Detectors for Compton Telescopes

Completed Technology Project (2018 - 2020)

Project Introduction

The objective of the proposed work is to demonstrate the suitability of artificial single-crystal diamond detectors (SCDDs) for use as the scattering medium in Compton telescopes for medium-energy gamma-ray astronomy. SCDDs offer the possibility of position and energy resolution comparable to those of silicon solid-state detectors (SSDs), combined with efficiency and timing resolution so-far only achievable using fast scintillators. When integrated with a calorimeter composed of fast inorganic scintillator, such as CeBr3, read out by silicon photomultipliers (SiPMs), SCDDs will enable a compact and efficient Compton telescope using time-of-flight (ToF) discrimination to achieve low background and high sensitivity. This detector development project will be a collaboration between the University of New Hampshire (UNH) and Southwest Research Institute (SwRI). The proposed work represents an innovative combination of detector technologies originally conceived separately for high-energy astronomy (fast scintillators read out by SiPMs; UNH) and space plasma/particle physics (SCDDs; SwRI). Recently SwRI has demonstrated that SCDDs fabricated using chemical vapor deposition (CVD) show good energy resolution (~7 keV FWHM), comparable to silicon SSDs, with much faster time response (~ns rise time) due to higher electron/hole mobilities. They are also temperature- and light-insensitive, and radiation hard. In addition, diamond is low-Z, composed entirely of carbon, but relatively high-density (3.5 g cm-3) compared to silicon or organic scintillator. SCDDs are therefore an intriguing possibility for a new Compton scattering element: if patterned with ~mm-sized readout electrodes and combined with a fast inorganic scintillator calorimeter, SCDDs could enable a compact but efficient Compton telescope with superior angular and energy resolution, while maintaining ToF background rejection. Such an instrument offers the exciting potential for unprecedented sensitivity, especially at energies < 1 - 2 MeV, on a small-scale mission utilizing recently available SmallSat buses (payload mass <100 kg). We propose to demonstrate this by constructing and testing a small proof-of-concept prototype and, based on its performance, using Monte Carlo simulations to explore the possibilities of furthering MeV science using relatively small-scale space missions.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of New Hampshire-Main Campus

Responsible Program:

Astrophysics Research and Analysis

Diamond Scattering Detectors for Compton Telescopes

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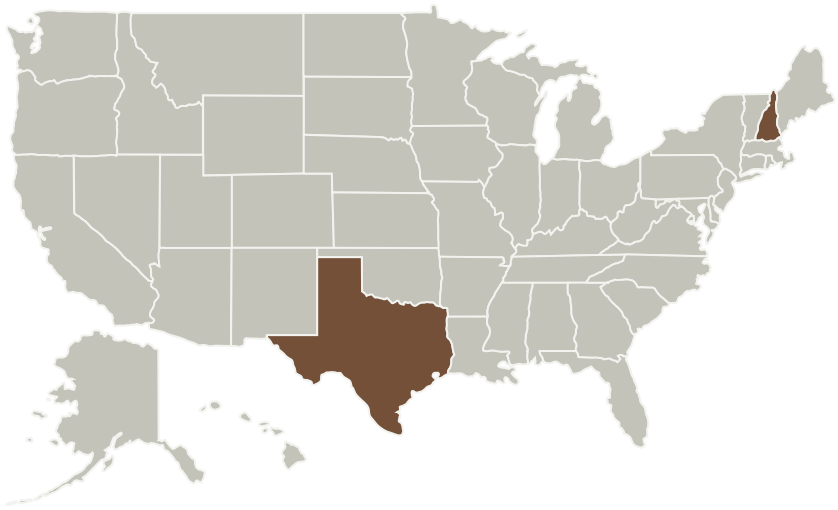
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of New Hampshire-Main Campus	Lead Organization	Academia	Durham, New Hampshire
Office of Sponsored Research and Programs - NC Central University	Supporting Organization	Academia	Durham, New Hampshire
Southwest Research Institute - San Antonio(SWRI)	Supporting Organization	Academia	San Antonio, Texas

Primary U.S. Work Locations	
New Hampshire	Texas

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Peter F Bloser

Co-Investigators:

Lisa Scigliano
Mark Mcconnell
Keiichi Ogasawara
James M Ryan

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System